

NEARSHORE GULF ECOSYSTEM

Diagram and Documentation

by

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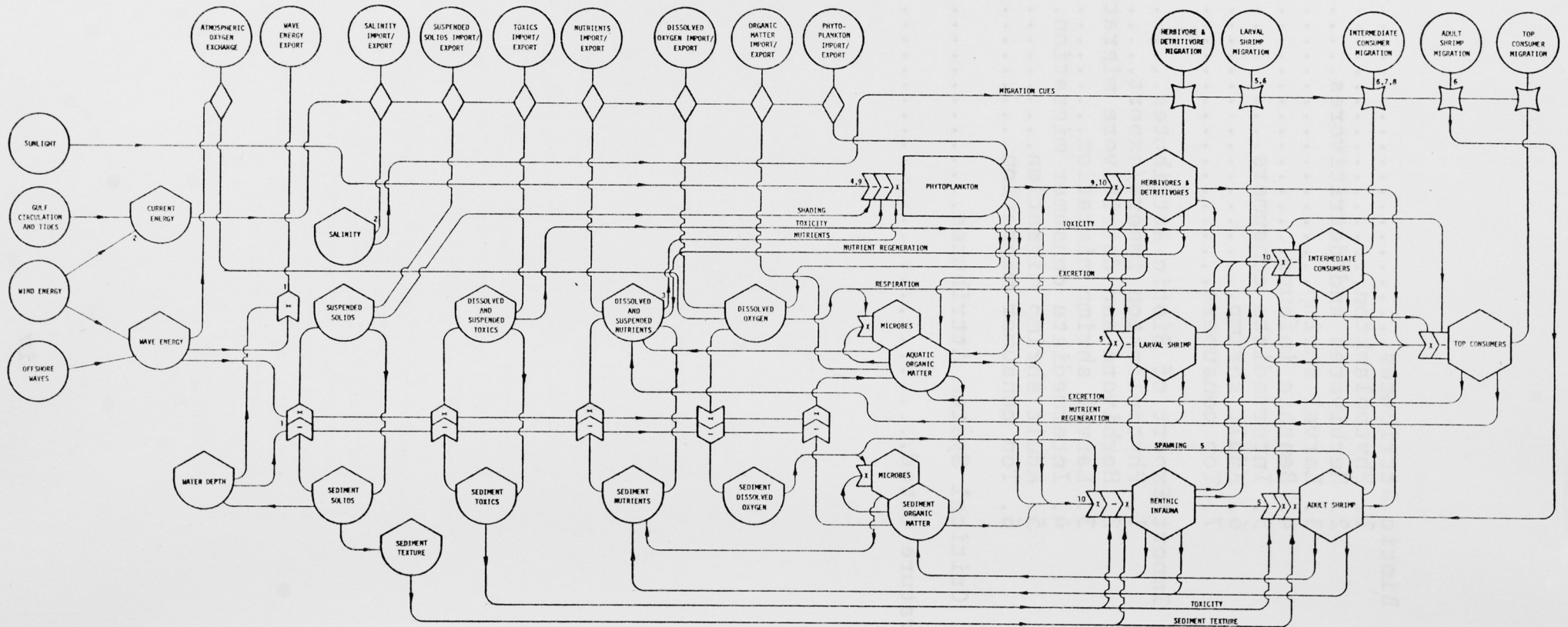
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1. U.S. Army Corps of Engineers, 1977.
2. Smith, 1975, 1978, 1979.
3. Sackett and Brooks, 1979.

4. Kamykowski and Van Baalen, 1979.
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NEARSHORE GULF ECOSYSTEM

I. INTRODUCTION - PURPOSE OF THIS DOCUMENT

This report has been prepared to accompany and to provide supporting documentation for the ecological system diagram of the Nearshore Gulf. The ecosystem diagram concept and its application to the assessment of activities in the coastal zone has been documented in technical papers of the Texas Coastal Management Program. In particular, Technical Paper #12 describes the theory, methods of construction and examples of diagrams for other coastal ecosystems. This report was prepared with support from the General Land Office of Texas.

II. SUMMARY AND OVERVIEW OF THE NEARSHORE GULF DIAGRAM

A. Physical Description

For the purposes of this document, the Nearshore Gulf is considered to be that portion of the inner continental shelf of Texas that lies inside of the three league line, outside of the surf zone and outside of those areas at the mouths of rivers and the principal passes which are considered "Inlet-Tidal Delta" systems. Water depth along the inner boundary is about 5 meters, while the outer boundary lies in between 13 to 30 meters of water.

B. Primary Energetics

The most important energy inputs to this system are sunlight, wind and wave energy. Sunlight drives the photosynthesis by phytoplankton which forms the base of the food web. Wind and waves provide the mixing energy which brings regenerated nutrients from the bottom and lower water column up to the photic zone. Large amounts of wave energy are exported to the Upper Shoreface.

C. Major Regulating Factors

Nutrients and organic matter from the rivers and estuaries clearly exert a major influence on the base of the food web through primary productivity and detritus supply. Suspended solids may also play a significant role by limiting light penetration. Salinity appears to be a significant regulator of the migration of organisms.

D. Importance to Man

Many of the prominent estuarine organisms spend part of their life cycles within the Nearshore Gulf. This includes the Penaeid shrimp and many of the major sport and commercial organisms such as Redfish, Black Drum, Flounder, and Blue Crabs. Many species of forage fish, which are major food items for the sport and commercial fish, also spend part of their life cycles in the Nearshore Gulf.

E. Types of Impacts Anticipated

Major activities affecting the Nearshore Gulf at the present time include: dredging and spoil disposal, petroleum exploration and development, commercial fishing, sport fishing, and modification of fresh water and nutrient inputs. Temperature has been left out of the diagram in spite of its major regulatory role because none of man's activities are expected to significantly alter the temperature of the Nearshore Gulf. Although there is currently no evidence of toxic effects on organisms in the Nearshore Gulf ecosystem, provisions have been made in the diagram for tracing toxic effects.

III. DETAILED DESCRIPTION

A. Introduction and Physical Description

The "Nearshore Gulf" ecosystem, as mapped, extends from the outer boundaries of the "Upper Shoreface" and "Inlet-Tidal Delta" ecosystems gulfward to the three league line that forms the limit of the Texas Coastal Management Program's jurisdiction. A more general term for this system would be the "inner continental shelf". The depth ranges from 5 to 9 meters (15 to 30 feet) on the inner boundary to 13 to 30 meters (42 to 96ft.) at the three league line. The greatest depths, at the three league line, occur along the southern third of the Texas coast, while the shallowest occur offshore from Sabine Lake. The substrate of the Nearshore Gulf Ecosystem is primarily sand and mud. It is disturbed infrequently during normal weather, but can be extensively eroded during storms.

Although the Nearshore Gulf ecosystem's productivity is based on phytoplankton, the estuaries and rivers strongly influence the system with respect to nutrients, organic detritus, suspended solids, and the migration of many organisms. The Nearshore Gulf is of particular importance as

the spawning ground of many sports and commercially important organisms which spend part of their life cycle in the estuaries. Because of their overwhelming importance to commercial fishing in Texas, particular attention has been paid (in the diagram) to the life cycle of the Penaeid shrimp.

The concept that biotic communities on the continental shelf change with depth is well known. Although different authors suggest slightly different depth limits, there appears to be a distinct "inshore" fauna extending from roughly 3 or 4 meters (10 to 13 ft.) out to roughly 20 to 27 meters (65 to 89 ft.) of water depth. Chittenden and McEachran (1976) call this the "White Shrimp Grounds" fauna in contrast to the "Brown Shrimp Grounds" fauna which occur from about 22 meters (72 ft.) out to about 91 meters (300 ft.) of water depth. This inshore faunal area corresponds well with the "Nearshore Gulf" ecosystem of this report.

Man's activities can have both direct and indirect effects on this ecosystem. The direct effects, such as shrimp trawling, dredging, spoil dumping, pipeline construction, offshore oil platform construction and operation, and oil spills are obvious; but may be of less significance than the indirect effects. The indirect effects stem mainly from modification of the inputs of nutrients, suspended solids, and other inputs from the rivers and estuaries.

B. Energy Inputs

1. Sunlight

Solar energy input is the most important single energy source for the Nearshore Gulf ecosystem. The organic matter formed by photosynthesis, together with smaller amounts of organic matter from the rivers and estuaries, provide the base of the food web. Solar energy which is not absorbed by phytoplankton is stored and released as heat. Heat is not explicitly represented on the Nearshore Gulf ecosystem diagram since it is unlikely to be altered by man's activities.

2. Wind Energy

Wind energy is one of the major factors controlling circulation and wave action in the Nearshore Gulf system. This energy input varies seasonally, both in direction and

magnitude. Recent studies (Smith 1975 and 1978) have shown current velocities on the inner shelf to be approximately 15 to 25 cm/sec (0.3 to 0.5 knots) during the winter and around 10 cm/sec (0.2 knots) during the summer. The current direction correlates well with the wind direction over 1 to 2 week periods. Wind energy is ultimately derived from solar energy, but since this connection should not be altered by man's activities, it is not represented on the diagram.

3. Gulf Circulation and Tides

The affects of circulation and tides in the open Gulf on the Nearshore Gulf are definitely smaller than the direct wind input, but are still measurable. Changes in water level in the Gulf as a whole are of significance mainly in the shallower systems and are not shown on this diagram.

4. Offshore Waves

Waves generated by wind in the open Gulf are of major significance as a source of mixing energy within the system. This energy input is highly variable, both seasonally and daily.

C. Physical Attributes

1. Salinity

Salinity in the Nearshore Gulf ecosystem is much less variable than it is within the estuarine systems, however, significant variations do occur. In addition to the runoff from Texas' rivers, the influence of the "fresh" water plume from the Mississippi River is frequently observable in eastern portions of the Texas Nearshore Gulf during the late spring (Smith, 1979). Salinity values in the Nearshore Gulf ecosystem may range from 36.5 ppt, characteristic of the open Gulf, to below 20 ppt around "Inlet-Tidal Delta" areas. The lower values are more typical of the northeastern Texas coast, where the rivers are larger and the influence of the Mississippi River is stronger. Horizontal and/or vertical salinity gradients of a few parts per thousand are not uncommon in the Nearshore Gulf (Smith, 1979; Jones, Copeland and Hoese, 1965).

2. Current Energy

Currents in the Nearshore Gulf ecosystem are primarily wind driven as previously discussed. Smith (1975, 1978 and 1979) has studied the sub-surface currents of the Texas inner shelf in detail. His studies show that the current energy is largely directed parallel to the shoreline. However, there is frequently a cross-shelf component, especially during the winter. Currents cause the exchange of Nearshore Gulf waters with the offshore Gulf and Inlet-Tidal Delta ecosystems. Water exchange with the offshore systems may take place in the form of "rip current" like plumes which have been photographed from space (Lindner and Bailey, 1968).

3. Wave Energy

Wave energy is largely imported from the open Gulf, but is also generated within the system by wind. Most of the wave energy is exported to the Upper Shoreface system. Some is dissipated as the waves interact with the bottom. This interaction is primarily responsible for the resuspension of bottom sediments and acceleration of the diffusion of oxygen into the sediments.

4. Suspended Solids

Suspended solids are introduced into the water column by resuspension of bottom sediments and by import from the Upper Shoreface and Inlet-Tidal Delta systems. The strong contrast in suspended solids (as measured by light penetration) between the inner shelf and deeper Gulf waters is well known. This is presumably due to the fine clay particles settling out in the deeper, less turbulent waters.

5. Sediment Solids

This compartment of the diagram is used to represent the mass or volume of sediment within a particular area of the Nearshore Gulf. This is increased by settling of suspended solids and decreased by resuspension due to wave action. Two attributes are derived from "sediment solids" and used to represent other aspects of the sediment. These are sediment texture and water depth.

6. Water Depth

Water depth is a significant controller of wave energy via friction with the bottom and diffraction of wave

fronts. When the bottom interferes with the orbital motion of water particles in waves, the wave energy produces currents along the bottom. These currents can cause mixing of the bottom sediments thereby increasing the rate of diffusion of dissolved oxygen into the sediments.

The speed of propagation of waves in shallow water depends on depth, thus wave fronts which approach the coast may be altered in direction by the bottom contours. This effect may be highly significant in controlling the wave energy which is exported to the Upper Shoreface system. The Army Corps of Engineers "Shore Protection Manual" (Corps of Engineers, 1977) contains an extensive treatment of this phenomenon. Computer programs for estimating the effects of bottom topography on wave energy are given in Tanner (1974).

7. Sediment Texture

The substrate maps produced by the Bureau of Economic Geology for the Coastal Management Program provide an excellent summary of the sediment texture for the Nearshore Gulf system. Most of the area is "mud and silt" with some areas containing significant quantities of sand and/or shell. The sand content is higher near the boundary with the Upper Shoreface system.

8. Dissolved and Suspended Toxics

Toxic materials which could be introduced into the Nearshore Gulf include heavy metals, pesticides, industrial organic chemicals, well drilling fluids, crude oil and petrochemicals. Most toxic materials are easily adsorbed on particles. They then become quickly incorporated into the sediments.

9. Sediment Toxics

As stated above, toxic materials introduced into the water are likely to be adsorbed on particles and incorporated into the sediments. Contaminated sediments from dredging and drilling muds would be introduced directly into the sediments.

10. Dissolved and Suspended Nutrients

For the purposes of this diagram, "Nutrients" are considered to be the organic and inorganic materials required by phytoplankton for photosynthesis in addition to

light. In the Nearshore Gulf system, nitrate nitrogen is considered to be the limiting nutrient. This is indicated by the fact that it is exhausted before phosphate or silicate during phytoplankton blooms (Sackett and Brooks, 1979). Nutrients may exist in both dissolved form and adsorbed to the surface of particles. Sedimentation of particles, photosynthetic uptake and exchange with other systems can remove nutrients from the water column. The decomposition of organic matter by bacteria, the metabolism of higher organisms, the release of nutrients from the sediments and the exchange of nutrients with other systems can add nutrients to the water column.

11. Sediment Nutrients

The interstitial water and the solid particles in the sediments contain nutrients in both solid and dissolved forms. The slow decomposition of organic matter by micro-organisms and the activities of benthic organisms causes the release of nutrients such as ammonia, phosphate and trace metals. These nutrients can be released to the water by diffusion or by turbulent mixing of the sediments. This recycling of nutrients from the sediments is extremely important to the functioning of the Nearshore Gulf ecosystem.

12. Dissolved Oxygen

Exchange of oxygen with the atmosphere tends to keep dissolved oxygen levels near saturation in the waters of the Nearshore Gulf system. Sackett and Brooks (1979) found that average dissolved oxygen values varied seasonally over the Texas continental shelf. The values ranged from 4.51 to 6.95 mg O₂/l, with the highest values occurring during the winter. Expressed in terms of degree of saturation, average values ranged from 100 to 112 percent saturation. This indicates that temperature and salinity tended to control dissolved oxygen concentration.

13. Sediment Dissolved Oxygen

No direct measurements of this parameter in the Gulf of Mexico have been found. Most observations of sediment indicate that the surface deposits are oxygenated but the lower layers are anaerobic as evidenced by the presence of methane (Sackett and Brooks, 1979).

14. Aquatic Organic Matter/Microbes

The biotic component "microbes" is partially combined with the symbol representing dissolved and suspended organic matter in the water. Experience has shown that this combined symbol greatly simplifies the diagram without any loss of ability to analyze potential impacts. Dissolved organic matter is present in the waters of the Nearshore Gulf at levels on the order of 1.0 to 3.7 mg of organic carbon per liter (Maurer and Parker, 1972).

The bacteria are the most important of the microbes in the decomposition of organic matter in the Nearshore Gulf. The populations of bacteria respond rapidly to organic matter inflows and rapidly colonize organic particles. Thus, populations of microbes are higher near the shore and near Inlet-Tidal Delta systems. Typical numbers may range from 500 to 155,000 cells per liter of water (Oujesky and Van Auken, 1979). Significant numbers of fungi have also been found in the Nearshore Gulf ecosystem (Szaniszlo, 1979).

15. Sediment Organic Matter/Microbes

Because the action of waves tends to keep organic particles suspended in the water column, the concentration of organic matter in Nearshore Gulf sediments is relatively low. Jones (1960) found a mean concentration of 0.52 percent organic carbon in surface sediments.

The numbers of bacteria found in the sediments range from 0.05 to 1.6 million cells per cubic centimeter of sediment (Schwarz, 1979). In addition to the decomposition of organic matter and the release of inorganic nutrients such as ammonia and phosphate, the bacteria are believed to produce significant amounts of vitamin B-12 (Maurer and Parker, 1968).

D. Import/Export of Physical Attributes

1. Wave Energy Export

During normal weather, the Nearshore Gulf exports most of the wave energy it receives from offshore waves, plus that added by local wind, to the Upper Shoreface or Inlet-Tidal Delta systems. The amount exported, and to some extent the direction of propagation, is strongly influenced by the water depth, as previously discussed.

2. Salinity Import/Export

The Nearshore Gulf receives low salinity water from the rivers and estuaries via the Inlet-Tidal Delta system and from the Mississippi River plume via Gulf of Mexico currents from the northeast (Smith, 1979). Generally, the seaward edge of the Nearshore Gulf exchanges with higher salinity water from the central Gulf of Mexico. During drought periods, the Laguna Madre, Corpus Christi Bay and Aransas Bay may have salinities higher than that in the Gulf, thereby reversing the normal salinity gradient (Collier and Hedgpeth, 1950).

3. Suspended Solids Import/Export

The exchange of suspended solids between the Nearshore Gulf and its adjoining systems is extremely complex. Clearly, those Inlet-Tidal Delta systems at the mouths of rivers such as the Colorado, Brazos or Rio Grande must act as net sources of suspended solids. However, the presence of Tidal Deltas in many bay systems indicates that sediment can be carried into the bays, either from offshore or from the longshore drift system in the Upper Shoreface. Apparently, during normal weather, wave energy tends to carry bottom particles shoreward into the Upper Shoreface. However, during storms this sediment may be eroded and redeposited in the Nearshore Gulf.

4. Toxics Import/Export

In general, the Inlet-Tidal Delta systems will be sources of toxics such as pesticides and heavy metals which come from runoff and discharges. On the other hand, the Nearshore Gulf system can serve as a source of spilled crude oil and petroleum products to the other systems. Exchanges with offshore waters tend to export toxics (with the exception of oil spills). The Mississippi River plume may also act as a source of toxics.

5. Organic Matter Import/Export

The estuaries and rivers have distinctly higher levels of dissolved and suspended organic matter than the Nearshore Gulf (Maurer and Parker, 1972) and serve as sources. The Nearshore Gulf in turn acts as a source of organic matter to the offshore waters. While the Nearshore Gulf clearly exports significant amounts of organic debris such as driftwood, sargassum and other large particles to

the Upper Shoreface and thence to the Beach; the Upper Shoreface may export small detritus and dissolved organic matter to the Nearshore Gulf. Thus the net balance remains unclear.

6. Nutrient Import/Export

The generally observed gradient of nutrient concentrations and photosynthetic activity decreases going from the estuaries through the Nearshore Gulf to the offshore waters. This gradient indicates that estuaries are sources of nutrients for the Nearshore Gulf; while it, in turn, is a source for the offshore waters. However, the amounts and forms of these nutrients are by no means clear. The amount of nutrients transported in combined form as organic matter may greatly exceed the amount transported in inorganic form. In those areas where rivers directly enter the Gulf without passing through an estuarine system, the magnitude of nutrient supply can be calculated directly.

7. Atomospheric Oxygen Exchange

Wave energy promotes rapid exchange of oxygen between the air and water. This tends to reduce the magnitude of dissolved oxygen fluctuations caused by photosynthesis and respiration.

8. Dissolved Oxygen Import/Export

Dissolved oxygen is exchanged with adjacent aquatic systems such as the Inlet-Tidal Delta, Upper Shoreface and middle continental shelf. Sackett and Brooks (1979) found rather uniform distribution of dissolved oxygen over the Texas continental shelf, indicating that exchange of water between the nearshore and offshore areas has little effect on dissolved oxygen concentrations.

E. Biotic Attributes

1. Phytoplankton

Photosynthesis by phytoplankton is by far the greatest source of organic matter for the base of the food chain in the Nearshore Gulf. Many studies have tended to concentrate on the "net" phytoplankton (ie. the phytoplankton caught in a fine mesh net) which is mainly diatoms such as Skeletonema coastatum. However,

"nannoplankton" is probably of equal or greater importance to the total productivity (Kamykowski and Van Baalen, 1979).

Productivity measurements in the Nearshore Gulf have included carbon-14 fixation rates and chlorophyll "a" amounts. Kamykowski and Van Baalen (1979) sampled both parameters repeatedly along a transect from Port Aransas out into the open Gulf. They found levels of chlorophyll "a" typically ranging from 1.0 to 4.0 micrograms per liter of water ($\mu\text{g/l}$) at inshore stations except for values less than 0.5 $\mu\text{g/l}$ during June, July and August. The high levels were apparently associated with a pulse of nutrients from spring run-off. Carbon uptake rates as high as 24 milligrams of carbon per cubic meter per hour ($\text{mgC/m}^3/\text{hr}$) were observed, but most values ranged between 4.0 and 16.0 $\text{mgC/m}^3/\text{hr}$.

As shown in the diagram, phytoplankton energy flow is based on sunlight, stimulated by nutrients, and decreased by shading due to suspended solids and toxic effects. There is no evidence, in the literature searched, that indicates toxic effects on phytoplankton in the Texas Nearshore Gulf at this time.

2. Herbivores and Detritivores

There are a variety of organisms which feed on phytoplankton and organic detritus in the Nearshore Gulf ecosystem. The smallest are the ciliated protozoa which prey upon the nannoplankton. They are in turn fed upon by the larger zooplankton. Johansen (1979) found the protozoan biomass to be on the order of 10 to 20 percent of the larger zooplankton biomass.

Larger zooplankton include copepods, ostracods, amphipods, and the larvae of crustaceans, mollusks and fishes. The extent to which these organisms feed upon phytoplankton and detritus depends on the species and its life stage. The biomass of zooplankton in the Nearshore Gulf was found to average 34.1 mg dry wt per cubic meter by Park (1979). It was observed to be positively correlated with chlorophyll "a" and salinity.

Menhaden and Mullet and are the most common herbivorous fish in the Nearshore Gulf ecosystem.

3. Larval Shrimp

Due to the economic and biological significance of Penaeid shrimp, the literature on these organisms is extensive. Synopses of the biological data on the three major commercial species have recently been published: Lindner and Cook, (1978) on Penaeus setiferus (white shrimp); Costello and Allen, (1978) on Penaeus duorarum (pink shrimp); and Cook and Lindner, (1978) on Penaeus aztecus (brown shrimp). The following discussion and the discussion of Adult Shrimp, in a later section, draw heavily on these papers.

Spawning of white shrimp occurs largely in the Nearshore Gulf, where the young shrimp grow to 6 - 7 mm before entering the estuaries. Pink shrimp spawn further offshore. Brown shrimp spawn in offshore waters deeper than 14 meters. The eggs of all species sink to the bottom, however, the larvae and post-larvae are planktonic. The larvae apparently feed upon phytoplankton and small zooplankton.

4. Benthic Infauna

For the purposes of the Nearshore Gulf diagram, the complex benthic community has been simplified into a single compartment. These organisms range in size from nematodes to large polychaetes and molluscs. In most studies, the "meiofauna" are separated from the "macrofauna" by their ability to pass through a 0.5 mm seive. Nematodes are the most abundant of the meiofauna in Nearshore Gulf sediments (Pequegnat, 1979). Other groups observed include harpacticoids, kinorhynchs, foraminifera, and polychaetes. The macrofauna is dominated by polychaetes (Holland, 1979).

Several authors have suggested that the benthic fauna of the Nearshore Gulf form a community which is distinctly different from that found further offshore. Cluster analysis of benthic invertebrates from grab samples indicated five distinct depth related groups of infauna on the continental shelf (Holland, 1979). Defenbaugh (1979) suggested that there is an "inner shelf assemblage" found at depths from 4 to 20 meters on the Texas and Louisiana shelf. Many environmental factors such as salinity, temperature, organic matter supply and sediment texture are positively correlated to water depth. Therefore, this zonation may be related to water depth only indirectly.

5. Intermediate Consumers

This compartment is used for both free swimming intermediate consumers and those closely associated with the bottom. This includes a wide range of organisms from fish larvae to jellyfish. Table NSG-1 lists the species and food habits for the most prominent intermediate consumers.

6. Adult Shrimp

Adult Penaeid shrimp spend most of their time in association with the bottom; either buried in the sediment for protection or searching on the bottom for food. The white shrimp (P. setiferus) is the most common Penaeid shrimp of the inshore continental shelf. But the other Penaeid shrimp are also found in the Nearshore Gulf system as they migrate between the estuaries and the deeper water.

7. Top Consumers

Mammals such as Porpoises, reptiles such as sea turtles, and many species of fish such as sharks and most of the important gamefish are considered top consumers in the Nearshore Gulf system. Table NSG-2 lists the major species found in the Texas Nearshore Gulf. In most cases, these organisms do not migrate into the estuarine systems. Porpoises, sea turtles and some sharks have been found in estuarine waters. Of course, man also constitutes a major top consumer; especially of shrimp and gamefish.

F. Import/Export of Biotic Attributes

Much of the biota of the Nearshore Gulf is closely associated with estuarine ecosystems. These species pass into the estuarine systems via the Inlet-Tidal Delta ecosystem. Because of the ease of sampling, most studies of migration of Nearshore Gulf organisms have taken place in Inlet-Tidal Delta systems. Examples include Simmons and Hoese's (1959), and King's (1971) studies of Cedar Bayou and Copeland's (1965) study of emigration through Aransas Pass.

In view of the large number of species involved, the data given here must necessarily be limited. The user is referred to the above papers and general works such as Gunter (1945) for more details concerning organism migration.

TABLE NSC-1 INTERMEDIATE CONSUMERS OF THE NEARSHORE GULF

Scientific name	Common name	Life Stage
FISH		
<u>Micropogon undulatus</u>	Atlantic Croaker	A
<u>Cynoscion nothus</u>	Silver Seatrout	A,J
<u>Menticirrhus americanus</u>	Southern Kingfish	A
<u>Arius felis</u>	Sea Catfish	A
<u>Leiostomus xanthurus</u>	Spot	A
<u>Cynoscion arenarius</u>	Sand Seatrout	A
<u>Stenotomus caprinus</u>	Longspine Porgy	A,J
<u>Synodus foetens</u>	Inshore Lizardfish	A,J
<u>Syacium gunteri</u>	Shoal Flounder	A,J
<u>Centropristis philadelphicus</u>	Rock Seabass	A,J
<u>Stellifer lanceolatus</u>	Star Drum	A,J
<u>Trichiurus lepturus</u>	Atlantic Cutlassfish	A,J
<u>Peprilus burti</u>	Gulf Butterfish	A,J
<u>Polydactylus octonemus</u>	Atlantic Threadfin	A,J
INVERTEBRATES		
<u>Squilla empusa</u>	Mantis Shrimp	A,J
<u>Trachypenaeus similis</u>	Broken Neck Shrimp	A,J
<u>Sicyonia dorsalis</u>	Rock Shrimp	A,J
<u>Portunus gibbesii</u>	Portunid Crab	A,J
<u>Callinectes similis</u>	Blue Crab	A,J
<u>Callinectes ornatus</u>	Blue crab	A,J
<u>Loligo pealei</u>	Squid	A,J

Life Stage: A = Adult, J = Juvenile

References: Chittenden and McEachran, 1976; Wohlschlag, 1979;
Holland, 1979; Miller, 1965;; Hoese, 1965; Cole, 1977;
Moore, Brusher and Trent, 1970

TABLE MSG-2 TOP CONSUMERS OF THE NEARSHORE GULF

Scientific name	Common name	Life Stage
MAMMALS		
<u>Tursiops truncatus</u>	Atlantic Bottlenose Dolphin	A,J
REPTILES		
<u>Caretta caretta caretta</u>	Loggerhead	A,J
<u>Chelonia mydas mydas</u>	Green Turtle	A,J
<u>Lepidochelys kemp</u>	Atlantic Ridley	A,J
<u>Dermochelys coriacea coriacea</u>	Leatherback	A,J
FISH		
<u>Carcharinus limbatus</u>	Black-tipped Shark	A,J
<u>Carcharinus leucas</u>	Bull Shark	A,J
<u>Carcharinus obscurus</u>	Dusky Shark	A,J
<u>Carcharinus milberti</u>	Sandbar Shark	A,J
<u>Sphyrna tiburo</u>	Bonnethead	A,J
<u>Sphyrna mokarran</u>	Great Hammerhead	A,J
<u>Galeocerdo cuvieri</u>	Tiger Shark	A,J
<u>Negaprion brevirostris</u>	Lemon Shark	A,J
<u>Scomberomorus cavalla</u>	King Mackerel	A,J
<u>Scomberomorus maculatus</u>	Spanish Mackerel	A,J
<u>Pomatomus saltatrix</u>	Bluefish	A,J
<u>Megalops atlanticus</u>	Tarpon	A,J
<u>Istiophorus platypterus</u>	Sailfish	A,J
<u>Makaira nigricans</u>	Blue Marlin	A,J
<u>Caranx hippos</u>	Crevalle Jack	A,J

Life Stage: A = Adult, J = Juvenile

References: Clark and von Schmidt, 1965; Parker and Bailey, 1979; Hoese and Moore, 1977; Wade, 1962; Raun and Gehlbach, 1972.

1. Phytoplankton Import/Export

Phytoplankton move between the Nearshore Gulf and the estuarine systems via the water mass movement of the Inlet-Tidal Delta system. They are also exchanged with the Upper Shoreface and outer continental shelf systems via the water currents. Many of the phytoplankton species found in the Nearshore Gulf system are also found in these other systems. However, since the phytoplankton density is higher in the estuaries and lower in offshore waters (Kamykowski and Van Baalen, 1979), the estuaries act as a net source of phytoplankton while the Nearshore Gulf exports phytoplankton to offshore waters.

2. Herbivore and Detritivore Migration

The Striped Mullet (Mugil cephalus) and White Mullet (M. curema) are the most prominent members of the Herbivore and Detritivore class, both in the Nearshore Gulf and in the estuarine systems. Moore (1974) summarized the ecological data on these fish. The adults apparently migrate to the outer continental shelf to spawn, and then return to the Nearshore Gulf and estuaries. Striped Mullet, the most common species, spawn in fall and winter. White Mullet spawn in spring and summer.

3. Larval Shrimp Migration

Kutkuhn, Cook and Baxter (1969) studied the distribution of young Penaeid shrimp near the entrance to Galveston Bay. Postlarvae were found every month except November and December, with peak abundance in March and April. No correlation with salinity or temperature was found. However, Keiser and Aldrich (1976) believe that larval shrimp use salinity gradients to "navigate". Lindner and Cook (1970) indicate that White Shrimp enter the estuaries when they are about 7 mm in length. King (1971) discusses the correlation between the migration of Penaeid shrimp and physical factors, such as water temperature, in detail.

4. Intermediate Consumer Migration

Most of the fish in this category in the Nearshore Gulf spend part of their life cycle in the estuaries. They typically migrate into the estuaries as larvae or juveniles and emigrate to the Gulf as adults. The periods of migration extend over much of the year. For instance, Copeland (1965) found Micropogon undulatus (Atlantic Croaker) emigrating

over the entire year. Most species were found in six or more monthly samples. In general, however, a strong pulse of emigration was observed in the fall.

Simmons and Hoese (1959) observed a somewhat different pattern. They found Micropogon undulatus and Leiostomus xanthurus (Spot) emigrating from Cedar Bayou mainly during May and June, with a secondary peak in September. Apparently there may be considerable variation in the timing of migrations of various species due to presently unknown or poorly understood factors.

Emigration of Callinectes sapidus (Blue Crab) adults, observed by Copeland (1965), occurred from April to November, with a main peak in April and May. Simmons and Hoese (1959) observed a strong pulse of emigration of adult Paralichthys lethostigma (Southern Flounder) during the fall, while juveniles entered the estuaries from April through November. Dasyatis sabina (Southern Stingray) breeds in the bays during the summer. The adults and juveniles emigrate to the Gulf with the coming of cold weather (Sage et.al., 1972).

5. Adult Shrimp Migration

After several months of growth and maturation in the estuarine systems, adult shrimp begin to emigrate into the Gulf. The White Shrimp tend to stay in the Nearshore Gulf, while the Brown and Pink Shrimp continue out to greater water depths. Simmons and Hoese (1959) observed that emigration through Cedar Bayou occurred only at night. The emigration lasted from April to November with the heaviest emigration occurring in June and September. A similar extended period of emigration was observed by Copeland (1965).

6. Top Consumer Migration

Top consumers in the Nearshore Gulf include Porpoises, Sea Turtles, Sharks and large sport fish. Many of the sharks apparently spawn just outside the surfzone in the Upper Shoreface (Parker and Bailey, in press). Little is known about the movements of Porpoises in the Nearshore Gulf. Shane (1977) describes populations which live in the Aransas Pass area and suggests that there are separate offshore populations. Sea Turtles spend most of their life cycles in the open ocean, only returning to the Beach to lay their eggs. The young may spend some time in the Nearshore Gulf on their way to the open Gulf after hatching. Most of

the large fish that comprise the majority of the top consumers are pelagic and migrate only into the open Gulf. They are not directly dependent on the estuaries for any part of their life cycles.

G. Critical System Attributes

The most critical linkages for the continued productivity of the Nearshore Gulf appear to be the links with the estuarine and river systems. The supply of nutrients and organic matter from the estuarine systems and rivers clearly helps to maintain a high level of photosynthesis in the Nearshore Gulf. Among the biota, the Penaeid shrimp appear to be a critical stage in the food chain. They require suitable habitat in the estuaries during part of their life cycles.

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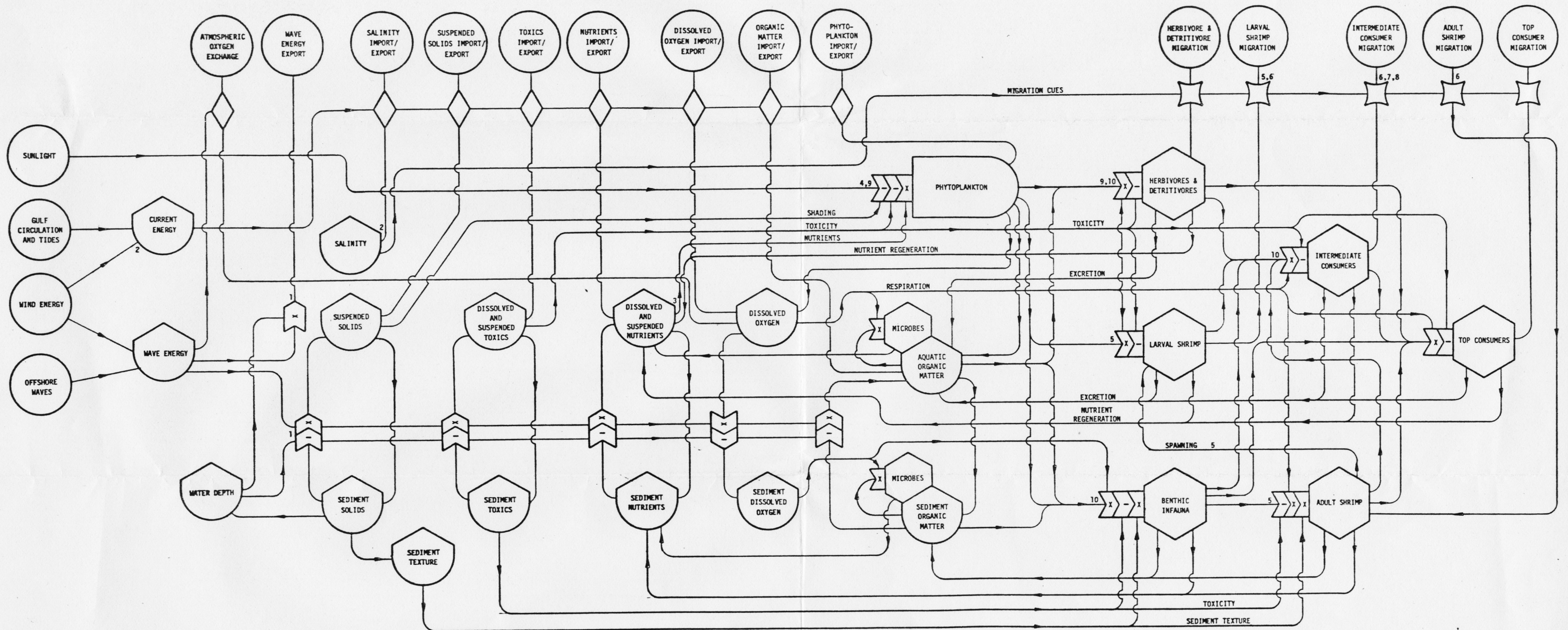
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NEARSHORE GULF ECOSYSTEM DIAGRAM



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